HIGHWAY SYSTEM SUBCLASSIFICATION BASED ON SYNTHESIS OF INTERCITY TRAVEL.

SEPTEMBER 1968

NO. 23

Joint Highway Research Project

PURDUE UNIVERSITY
LAFAYETTE INDIANA

by

W. C. VODRAZKA

and

H. L. MICHAEL

Technical Paper

HIGHWAY SYSTEM SUBCLASSIFICATION
BASED ON SYNTHESIS OF
INTERCITY TRAVEL

To: J. F. McLaughlin, Director
Joint Highway Research Project

September 12, 1968

Project No: C-36-54LL

From: H. L. Michael, Associate Director
Joint Highway Research Project

File No: 3-3-33

The attached Technical Paper "Highway System Subclassification Based on Synthesis of Intercity Travel" is presented to the Board for approval of publication. The paper has been authored by Messrs. W. C. Vodrazka and H. L. Michael of our staff and has been submitted to the Highway Research Board for possible presentation at the 1969 Annual Meeting. If accepted it will be published by the HRB.

The paper is a summary of the techniques used in the classification of Indiana highways according to their importance for intercity travel after the Interstate system of highways is completed. The report on this topic was presented to the Board and accepted by it at an earlier meeting in 1968.

The paper is presented for approval of publication by the Highway Research Board.

Respectfully submitted,

Harold L. Michael

Harold L. Michael
Associate Director

HLM:ms

cc: F. L. Ashbaucher
W. L. Dolch
W. H. Goetz
W. L. Grecco
G. K. Hallock
M. E. Harr
R. H. Harrell
J. A. Havers
V. E. Harvey
G. A. Leonards
F. B. Mendenhall
R. D. Miles
J. C. Oppenlander
C. F. Scholer
M. B. Scott
W. T. Spencer
H. R. J. Walsh
K. B. Woods
E. J. Yoder

Technical Paper

HIGHWAY SYSTEM SUBCLASSIFICATION BASED ON SYNTHESIS OF INTERCITY TRAVEL

BY

Walter C. Vodrazka, Research Engineer

and

Harold L. Michael, Associate Director

Joint Highway Research Project

Project: C-36-54LL

File: 3-3-38

Purdue University

Lafayette, Indiana

September 12, 1968

Introduction

Virtually every unit of government with an interest in highways can present a valid argument for a greater share of the highway dollar in order to adequately meet their respective responsibilities. This usually occurs for two reasons. One is the rising cost of both the materials and manpower required in all phases involved in the planning, design, construction, and maintenance of the highway plant. The other is the fact that even if unit costs for materials and manpower remain constant, overall costs are rising because the steady growth of highway traffic necessitates higher standards of highway design, construction and maintenance on more miles in order to render an acceptable quality of service. Certainly the need is great for an overall increase in the quality of service rendered by the existing highway mileage.

Because the number of highway dollars is severely limited, emphasis must be given to highway planning to ensure the wise investment of available funds. Moreover, the orderly, efficient, and economical development of a state highway system, or any other arterial system, requires that all segments of it, ranging from the highest type freeways and expressways to secondary collector roads and streets, be included in the improvement and maintenance programs developed within the framework of the planning process.

Among the first steps involved in the planning process are the classification of the highway network into various systems and the determination of needs (deviations from tolerable or ideal conditions) within each system. The roads within a system, for example, the state highway system, are not alike either in respect to the service provided,

which may range from strictly traffic movement to a significant amount of land access service, or in their design, construction, and maintenance standards. Dollar, manpower, equipment and management requirements also vary within the system.

This suggests, therefore, that proper highway planning should include the subclassification of the highway system into several subsystems such that the highways within each subsystem are characterized by similar function or character of service as well as similar standards of development.

The purpose of this paper is to describe a procedure which was used to subclassify the rural State Highway System of Indiana and to select a subsystem of the more important rural highways to supplement the Interstate system in the movement of large volumes of high speed traffic. This subsystem of highways was deemed, in the future of the anticipated intercity travel demand, worthy of consideration for construction to design standards equal or comparable to those of the Interstate system.

Study Approach

Two important factors led to the selection of the methods employed in the research discussed in this paper. Traffic patterns as they now exist on the State highway system will undoubtedly change as more drivers are able to take advantage of the fast developing Interstate system. The second factor was that highway improvements needed to be concentrated on existing routes. Highway improvement programs are not generally necessary to obtain more highways but to obtain improved and more adequate highways (8).

Because of the second factor, the Indiana state highway system as it existed in 1966 was used as the base for the analysis with one very significant alteration. This was the assumption that the entire Interstate system was complete and fully operational. Thus, the analysis of traffic patterns reflected changes resulting from motorists utilization of a completed Interstate system. It is important to recognize that any recommendations regarding system designation made as a result of this study are predicated on the completion of the presently proposed Interstate system.

The objective of the study was to predict traffic patterns in Indiana as they would exist today, if the completed Interstate existed today, and then to project these traffic patterns to future years.

A statewide study of intercity travel desire was selected as the method to provide a synthesis of traffic patterns on the State highway system. This was done for several reasons. The state highway system primarily serves intercity travel of a non-local nature. While the existence of other major traffic generators such as universities, parks, and military bases was recognized, it was felt that their effect would be masked on roads with a high concentration of intercity travel and, therefore, be of most significance on roads with a low concentration of intercity travel. Roads thus likely affected could then best be handled as special cases in the process of subclassification.

Another reason for selecting the intercity travel desire method was the hope that the use of this method would result in the assignment of a numerical factor to each highway section in the State, the magnitude of which would be a measure of both the relative importance and anticipated

traffic volume of each highway section. It was further envisioned that some function of the importance of a highway section and its overall condition as measured by a sufficiency rating could be used to establish a set of relative priorities for reconstruction and maintenance.

The only variables in the selected intercity travel desire model were city populations and the distances between each city pair. These items of data are readily available and may be updated on a regular basis. Thus, the analysis may be repeated on a continuing basis and highway system designations modified to reflect changes in population and in the highway system itself.

Intercity Travel Desire Factors

The intercity travel desire factor (ITDF) model used in this study is based on the gravity concept of human interaction. A basic postulate of this concept is that the interaction between cities varies directly with some function of the populations of the two cities and inversely with some function of the distance between them. This may be expressed as:

$$ITDF_{ij} = f(Pi, Pj)/f(d_{ij})$$

The functional form used was the product of the square roots of the populations of a city pair divided by the square of the minimum path distance between the two cities. This was the same form used with some success in studies carried out in Washington (4) and New Mexico (5).

The first step in the analysis was the coding of the highway network and the location of all cities. A highway system can readily be visualized as a network consisting of a set of nodes representing highway intersections and a set of links representing the portion of

a highway connecting two nodes or two intersections. By properly numbering the nodes and generating a table containing all the links and their lengths, a complete numerical description of a highway system can be made available for computer operations.

Through the use of an appropriate algorithm it is then possible to determine the minimum path distance between any two cities located anywhere in the network as well as the route employed in achieving this minimum path distance. The highway network as used in this study was quite large, consisting of approximately 4,520 nodes and cities and about 6,340 links. In fact, the network was so large that a Tree Type Decomposition Algorithm for Minimum Paths in Large Networks had to be developed in order to solve the problem on the available computer (1).

The delimited area in which a fine degree of network detail was required is illustrated in Figure 1. With the exception of some short access routes to public installations, all states within Indiana were coded. Also coded were the major routes of adjacent states within 100 miles of Indiana. Beyond this point, only Interstate routes were considered.

The ten nodes shown at or near the periphery of the delimited area of Figure 1 indicate Interstate highway intersections through which intercity travel, with at least one city located outside the delimited area, must pass if any Indiana highways are included in the minimum path. The "Key" of Figure 1 serves to point out the six decomposed networks used in the minimum path algorithm.

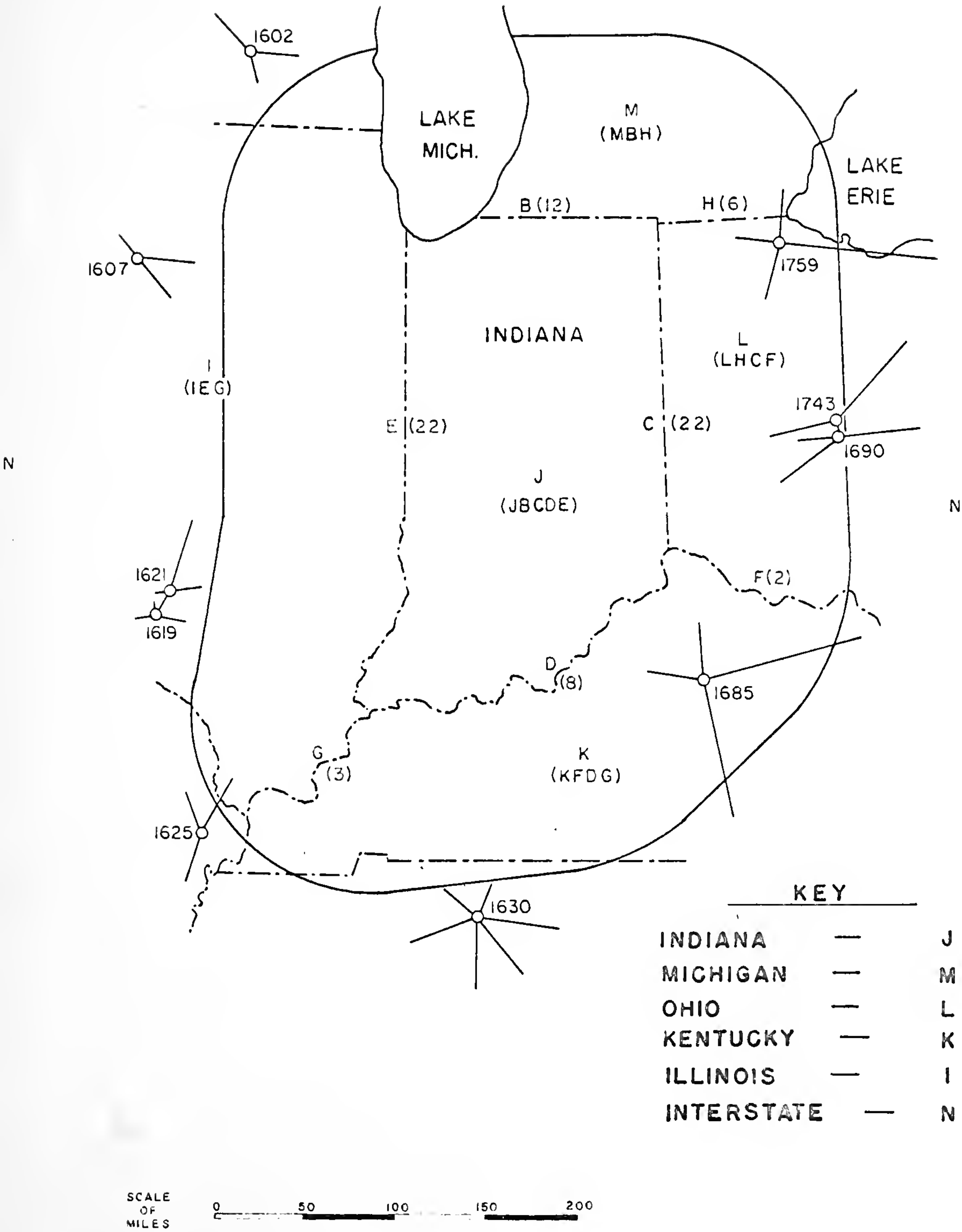

FIGURE 1. DELIMITED AREA OF THE PARTITIONED NETWORKS.

The next step in the procedure was the determination of the minimum path distance and route between all city pairs. The ITDF was then calculated for a city pair and this value assigned to each link of the minimum path. A cumulative total of these ITDF factors was maintained for each of the 1,809 links contained in the Indiana highway network.

This step was actually carried out in three phases with the cumulative total of ITDF link assignments kept separately for each phase. The phases were: I) all city pairs with both cities more than 100 miles from Indiana; II) all city pairs with at least one city in Indiana; and III) all city pairs with at least one city within 100 miles of Indiana but neither within Indiana. However, only those ITDF factors calculated in Phase II were considered in the final analysis because early analyses showed that the influence of the factors for phases I and III were not significantly different from zero.

The link lengths as used in the network description were not true distance measures but were actually time measures in minutes. The length of an Interstate link in miles was numerically equal to the travel time in minutes because it was estimated that Interstate highways could be negotiated at a speed of 60 MPH. All other highway link lengths were multiplied by a ratio to convert miles to minutes. The speed on a four-lane rural highway was estimated to be 50 MPH and a ratio of 1.2 was used to make the conversion. The speeds estimated for two-lane rural, four-lane urban and two-lane urban highways were respectively 45, 30, and 15 MPH with ratios of 1.33, 2.0, and 4.0. This allowed for some discrimination in the selection of already existing, higher-type facilities within the mechanics of the minimum path algorithm.

A total of 451 cities and towns in Indiana, each with a population of 100 or more, were coded as centroids and linked to appropriate highway nodes. Within the delimited area outside of Indiana, 675 cities of over 1,000 population were coded while another 1,639 cities of over 5,000 population located outside the delimited area also were coded. In all cases where cities were within five miles of each other, their populations were summed and treated as one city in subsequent calculations.

The calculation of all intercity travel desire factors was subject to the following restrictions:

1. Cities of less than 1,000 population had interactions only with cities within 150 miles of their location.
2. Cities with a population between 1,000 and 5,000 had interactions only with cities within 300 miles of their location.
3. Only cities with greater than 5,000 population had interactions with cities located outside of the delimited area.
4. The population of the larger of a pair of cities was limited to a maximum value of ten times the population of the smaller city.

These restrictions were imposed in an attempt to overcome some objections to a gravity model approach to travel synthesis, the principal objection being that use of this approach implies a virtually unlimited trip generation capability of each centroid. The distance limitation controlled the sphere of influence of the smaller cities while the factor of ten limitation on population prevented the calculation of unrealistic trip potentials when a small city interacted with rather large ones. The basis for the numerical values of the imposed limitations was that they appeared reasonable.

Analysis of Intercity Travel Desire Factors

A centroid and a link analysis of the computed desire factors was performed to demonstrate the adequacy of the assumed ITDF model to synthesize travel and to establish a relationship between link factors and link volumes.

Centroid Analysis

It has previously been stated that the completion of the Interstate highway system and its subsequent utilization by traffic will result in changes in the traffic patterns now existing on the State highway system. Because of the fact that the Interstate system was assumed to be completed in the performance of this study, the factors should reflect travel patterns not as they currently exist but as they would exist if the Interstate system were complete. For this reason, it was decided that the establishment of a relationship between link volumes, as they currently exist, and link factors for all highway links would not provide an adequate means of demonstrating the adequacy of the ITDF model to synthesize travel.

However, it was reasoned that eventthough the traffic patterns would be different, the relative magnitude of traffic attracted by individual centroids would not greatly be affected by assuming a completed Interstate system. This implies that the traffic attracted to a centroid should be essentially the same with a completed Interstate system but that it may enter the centroid today on different links. It was, of course, recognized that the amount of traffic which currently passes thru a city might be significantly altered if the Interstate system were complete.

The impact of this latter effect on the total traffic entering or leaving a city, hhowever, decreases as city size increases as shown in Table 1 from Matson, Smith, and Hurd (9). Table 1 gives the per cent of traffic entering a city which may be bypassed (traffic not desiring to stop in the city) around the city as a function of city size. The percentage of bypassable traffic for cities from 10,000 to 300,000 population is relatively uniform appearing to average about 20 per cent. Because of the high proportion of traffic having a terminus in these cities, it appeared reasonable to expect that a significant relationship should exist between the sum of the computed factors and the sum of the traffic volumes for the links entering such cities even if significant changes in thru traffic would occur with a completed Interstate system, provided that the ITDF model was adequate. In other words, a high percentage of the variability of traffic volume should be explained by a regression of the sum of the traffic volumes for the links serving the centroid on the Phase II centroid factor.

The Phase II centroid attraction factor was available because of the way the highway network was coded. The sum of the Phase II desire factors associated with all the links entering a city could be separated into a centroid attraction factor and a thru factor. The centroid attraction factor was that portion of the total desire factor calculated when the city served as an origin or destination for interaction with other cities. This distinction could not be made for individual links but only for the sum of all links of a centroid.

Table 1. Proportion of Approaching External Traffic Which May Be By-passed Around A City.

Cities by Population Size	Per Cent Bypassable Traffic
less than 2,500	[illegible]
2,500 - 10,000	[illegible]
10,000 - 25,000	[illegible].9
25,000 - 50,000	21.[illegible]
50,000 - 100,000	6.2
100,000 - 300,000	[illegible]
300,000 - 500,000	[illegible].2
500,000 - 1,000,000	[illegible].2

The dependent variable Y was taken as the sum of the Annual Average Daily Traffic (AADT) estimates on all highways entering a city as measured just beyond the city limits. This data was collected from the 1962 Traffic Map as furnished by the Indiana State Highway Commission. Traffic volumes for 1962 were used because they were the most contemporary available for the entire state in conjunction with the 1960 population figures used in calculating the desire factors. The independent variables were various measures of the computed travel desire factors associated with the links entering each centroid.

Data for a total of 390 Indiana centroids were coded for use in this analysis. These data sets were divided into three centroid population groups. The first group consisted of 69 centroids, each with a population of over 5000; the second of 167 centroids, each with a population between 1000 and 5000; and the third of 154 centroids, each with a population between 100 and 1000. A regression analysis was performed on each of these three data sets as well as on the total of 390 data sets.

The division of data sets by population was performed to test the reasoning that the adequacy of the ITDF model would decrease as population decreased, as measured by the per cent of variability of the dependent variable explained by the independent variables. The per cent of variability explained is commonly referred to as the coefficient of determination or the square of the correlation coefficient (R^2) in regression analysis.

It was also expected that an increase in R^2 would occur when the thru factors associated with the links serving a centroid were included in the analysis. However, it was also recognized that a serious problem concerning the effects of local traffic existed for the smaller cities in addition to the thru traffic effects. The situation as it generally exists for small cities is that traffic volumes on roads entering the city are correspondingly small. A good deal of this traffic may be bound for the city but be local in character. The amount of local traffic is a function of the population density in the surrounding area and the degree of agricultural and other economic development. These factors have wide variation throughout the State so that a similar variation should be expected in the amount of local traffic as well.

It may be argued that a good deal of the traffic on roads entering a large city may be bound for the city but be local in character as well. However, a larger city has many county roads and other highways entering it which are not part of the State highway system but which carry large amounts of local traffic. A small city has few of these other roads and much local traffic must use a State highway to reach the city. This suggests that a larger proportion of the local traffic enters a large city on local roads than is the case for a small city. Accordingly, more of the traffic on State highways entering large cities is of the type that the intercity travel desire factors measure than is the case for State highways entering a small city.

Each of these effects serve to force a decrease in R^2 as city size decreases because the amount of thru and local traffic assumes a much greater significance with respect to the total traffic entering the city than does the intercity traffic attracted by the city. This would be expected to occur even if the ITDF model perfectly explained intercity travel desire.

The results of the regression analyses performed on the centroid data are given in Table 2. The values of R^2 are shown to range from 0.829 to 0.218 to 0.116 for large, medium, and small city sizes respectively when the centroid attraction factor is the only independent variable. However, the values of R^2 are increased to 0.873, 0.428, and 0.291 respectively when the thru factor measure (of Phase II) also serves as an independent variable. These results are in agreement with the discussion given above.

The values of R^2 for the data taken as a whole range from 0.816 when the centroid attraction factor is the only independent variable to 0.866 when the thru factor measure is also included.

Based on these results, it appears reasonable to conclude that the assumed ITDF model is an adequate measure of intercity travel desire.

A perplexing aspect of the models developed in this analysis, however, is the negative sign of some of the coefficients for the Phase I and Phase III thru factors, i.e., X_3 and X_4. (See Table 2). The implication is that traffic decreases as the thru factors associated with a centroid increase. This makes no sense at all.

An explanation for this occurrence is an extension of the thru traffic effect as described previously. Thru traffic makes up a relatively small proportion of the external traffic entering a city and it may be assumed that the type of thru traffic measured by the Phase I and Phase III factors constitutes a very small proportion of the thru traffic. Thus, other traffic variations such as local traffic probably overwhelm any variability in traffic volume that may be explained by the Phase I and Phase III factors. This was borne out by examination of the standard errors which revealed that many of the coefficients of X_3 and X_4 are not significantly different from zero.

Table 2. Regression Models Developed in the Centroid Analysis.

Dependent Variable	Parameter	Independent Variables X_1	X_2	X_3	X_4	R_2
$Y_{(>5000)}$	Coeff.	70.62	---	---	---	0.829
	Std. Err.	3.92	---	---	---	
	Coeff.	55.72	2.63	---	---	0.873
	Std. Err.	4.65	0.50	---	---	
	Coeff.	55.56	4.16	-1.61	-2.24	0.879
	Std. Err.	4.61	0.98	2.18	1.69	
$Y_{(1000-5000)}$	Coeff.	42.66	---	---	---	0.218
	Std. Err.	6.28	---	---	---	
	Coeff.	21.55	[illegible]	---	---	0.423
	Std. Err.	6.04	0.37	---	---	
	Coeff.	27.17	4.64	4.54	7.30	0.479
	Std. Err.	5.87	0.65	1.56	[illegible]	
$Y_{(<1000)}$	Coeff.	61.48	---	---	---	0.116
	Std. Err.	[illegible]	---	---	---	
	Coeff.	[illegible]	2.27	---	---	0.297
	Std. Err.	13.15	0.37	---	---	
	Coeff.	20.23	6.63	1.00	[illegible]	0.419
	Std. Err.	12.25	[illegible]	1.48	[illegible]	
$Y_{(ALL)}$	Coeff.	56.61	---	---	---	0.816
	Std. Err.	1.42	---	---	---	
	Coeff.	47.85	2.77	---	---	0.866
	Std. Err.	1.51	0.23	---	---	
	Coeff.	47.34	4.37	-0.36	-.98	0.872
	Std. Err.	1.48	0.43	0.95	0.80	

Y = Sum of AADT'S on links entering a centroid.
X_1 = Sum of Phase II centroid attraction factors.
X_2 = Sum of Phase II thru factors
X_3 = Sum of Phase I thru factors
X_4 = Sum of Phase III thru factors

The high value of some of the Phase I and Phase III factors led to the conclusion that they were overestimated relative to Phase II factors. In other words, the ITDF model yielded too high an intercity travel desire for the very long interactions characteristic of Phase I and Phase III. Many of these long trips are either not made at all or are made by another mode such as plane or train. Thus, for long distance trips of say 300 to 400 miles or more, the exponent of distance in the ITDF model should be some value greater than two.

Link Analysis

A link analysis was performed to develop a relationship between link volumes and link factors. A regression analysis of the minimum AADT associated with a link on the Phase II link factor was performed to develop this relationship.

The minimum AADT on a link (the lowest AADT of a section of the link) was used as the dependent variable because the minimum value would more closely reflect intercity travel. In an idealized relationship, it can be observed that local traffic will increase as a centroid or route intersection is approached but intercity traffic will remain constant. Thus, the minimum traffic volume more closely represents what the ITDF model measures.

The link data used in this analysis were selected to meet one of two criteria: the link was located in an area remote from an Interstate highway or the link was located near a portion of the Interstate system completed prior to 1962. These criteria were imposed in an attempt to insure that travel patterns for 1962 in the areas of the selected links would not be significantly affected by completion of the entire Interstate System.

After the link data had been collected and plotted on a scatter diagram, it was decided to eliminate those data sets having a Phase II link factor of less than 50 and to try a functional relationship of the form:

$$Y = a + b \text{ Log } (X)$$

where Y is the minimum link AADT and X is the Phase II link factor.

A total of 126 data sets were used in this analysis. The regression model developed was:

$$Y = -8977 + 5523 \text{ Log}_{10} (X)$$

which had an R^2 of 0.919. A plot of this equation is shown in Figure 2.

The variance of the estimate, $s_{\hat{Y}}^2$, of a predicted Y for a given X is estimated by:

$$s_{\hat{Y}}^2 = s_E^2 \left[1 + \frac{1}{n} + \frac{(X - \bar{X})^2}{\sum (X - \bar{X})^2} \right]$$

For X equal to the mean, the variance of the estimate is given by:

$$s_{\hat{Y}}^2 = 551{,}412 \left[1 + \frac{1}{126} + \frac{(2.377 - 2.377)^2}{25.43} \right]$$

and the standard error of the estimate, $s_{\hat{Y}}$, equals 745.5.

The standard error of the slope was 147.3 so that the 95 percent confidence interval extended from 5,234 to 5,812.

Based on this analysis, it was decided that the regression model was an adequate means of predicting the traffic volume associated with the Phase II link factor. Furthermore, these results reinforce the conclusion that the ITDF model used is adequate for the synthesis of travel demand.

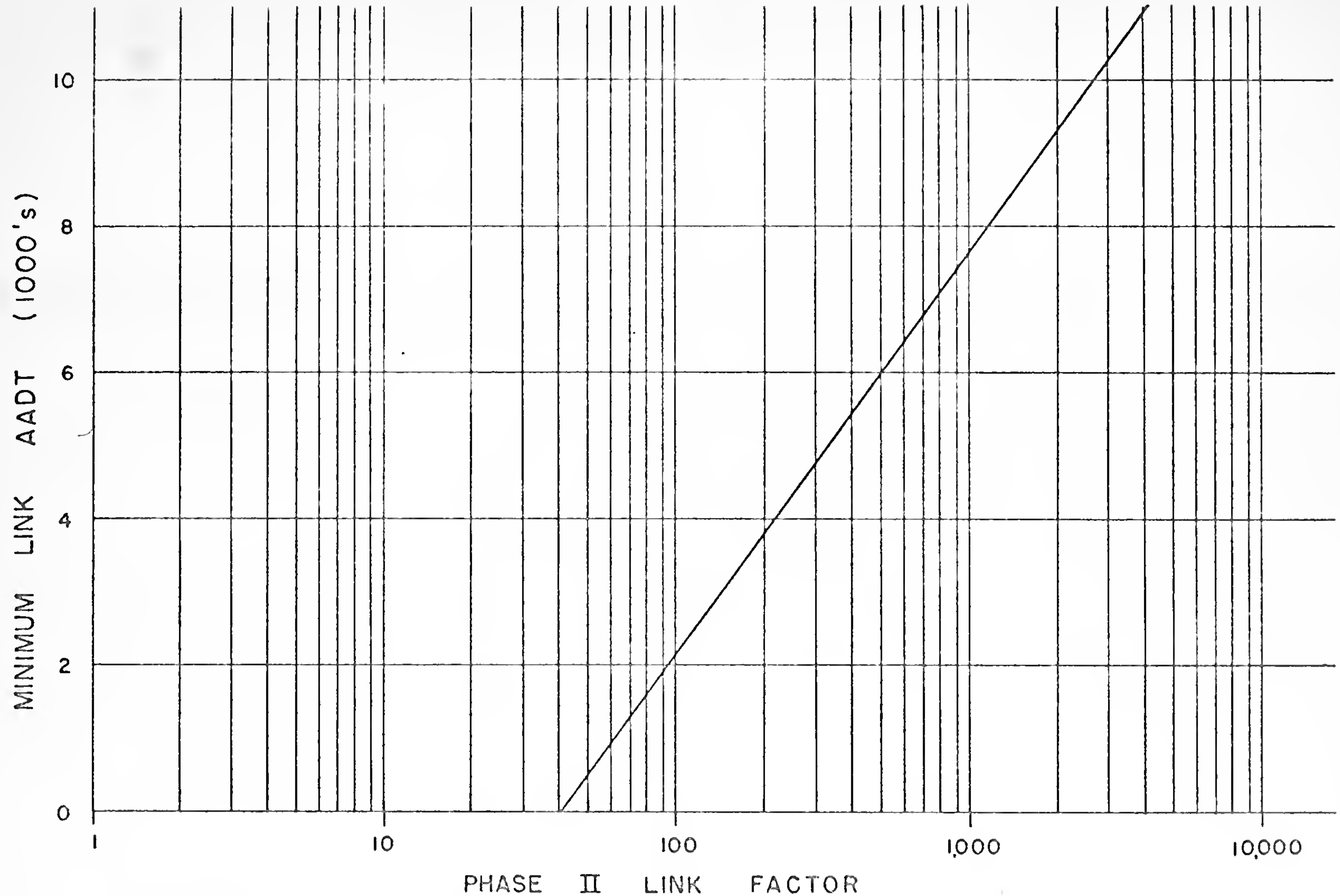

FIGURE 2 LINK VOLUME AS A FUNCTION OF LINK FACTOR

Application of Results

It was suggested after study of the requirements for various classes of the State Highway System of Indiana that it be subclassified into four designated systems. These four subsystems are:

1. Principal State Highway System. This system should be composed of the presently designated Interstate highway system and those highways which, on the basis of their Phase II Intercity Travel Desire Factor and other planning criteria should be reconstructed to freeway standards by 1982. The design year was selected as 1982 because the AADT-link factor relationship was based on 1962 volume data thus providing a 20-year planning interval. A Phase II link factor of 180 or greater was found for such highways.

2. Primary State Highway System. This system should be composed of the additional highways required to provide for the interconnection with the Principal State Highway System of all Indiana cities over 5000 population and other roads with moderately heavy intercity travel. A Phase II link factor of at least 125 was found for these roads.

3. Secondary State Highway System. This system should be composed of the additional highways required to provide for the interconnection with the previously designated subsystems of all still unconnected county seats and other roads with light but significant intercity travel. A Phase II link factor of at least 50 was found to be an adequate measure of the latter.

4. Collector State Highway System. This system should include the remainder of the present State Highway System of Indiana not already in a previously designated subsystem.

The proposed Principal State Highway System for 1972 and 1982 is shown in Figure 3. The routes proposed as supplementary to the Interstate system are shown in two groups. The first consists of freeways deemed necessary by 1972 and the second, freeways deemed necessary by 1982.

In general, when the AADT of a two-lane, two-way highway is between 7,000 to 8,000 vehicles per day, serious consideration should be given to making it a multilane facility with the degree of access control determined by individual study. If the design hour volume (DHV) is taken at about 15 per cent of the AADT, its magnitude is 1,050 to 1,200 vehicles per hour for AADT's of 7,000 to 8,000 respectively. According to the "Highway Capacity Manual" (10), the service volume for level of service C for such a highway approaches 1400 passenger cars per hour under ideal conditions while the service volume for level of service B approaches 900 passenger cars per hour under ideal conditions. These are the two levels of service usually associated with the design of rural highways.

The service volume at level of service C for a two-lane highway with adequate lane and shoulder width, no passing sight distance or alinement restrictions, and only 10 per cent trucks is about 1,200 vehicles per hour. Thus, demand volumes of 1,200 vehicles per hour virtually dictate multilane design for future increases in volumes even if ideal conditions can be designed into a two-lane highway and if a desirable level of service is to be attained.

The selection of the Phase II link factor limits used to select this subsystem of highways was based on a projected volume of 7500 vehicles per day assuming an annual average growth rate of four per cent. Highways in Indiana which will be carrying this volume of traffic

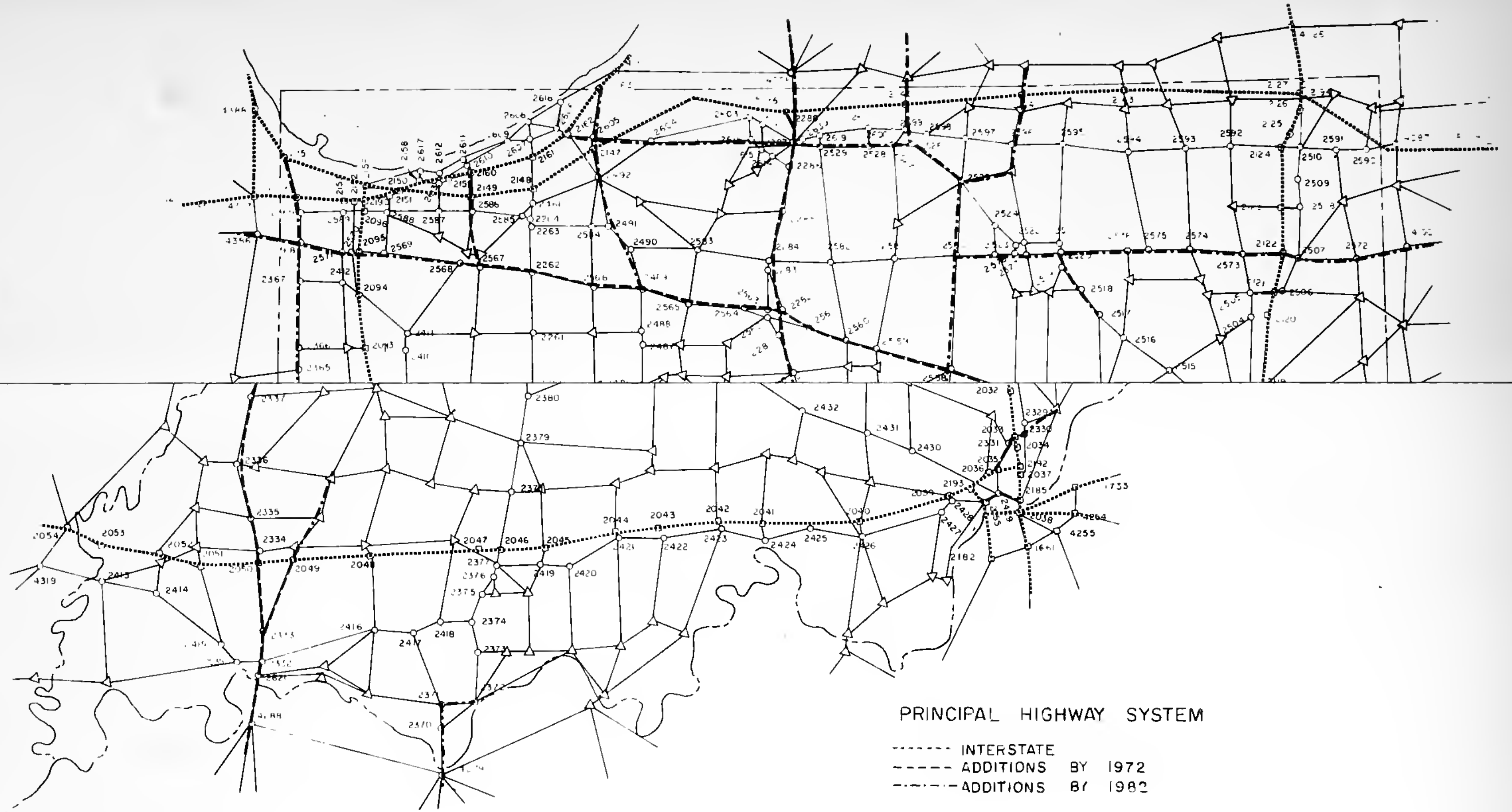

FIGURE 3. PROPOSED PRINCIPAL STATE HIGHWAY SYSTEM OF INDIANA - 1972 AND 1982 PROJECTIONS

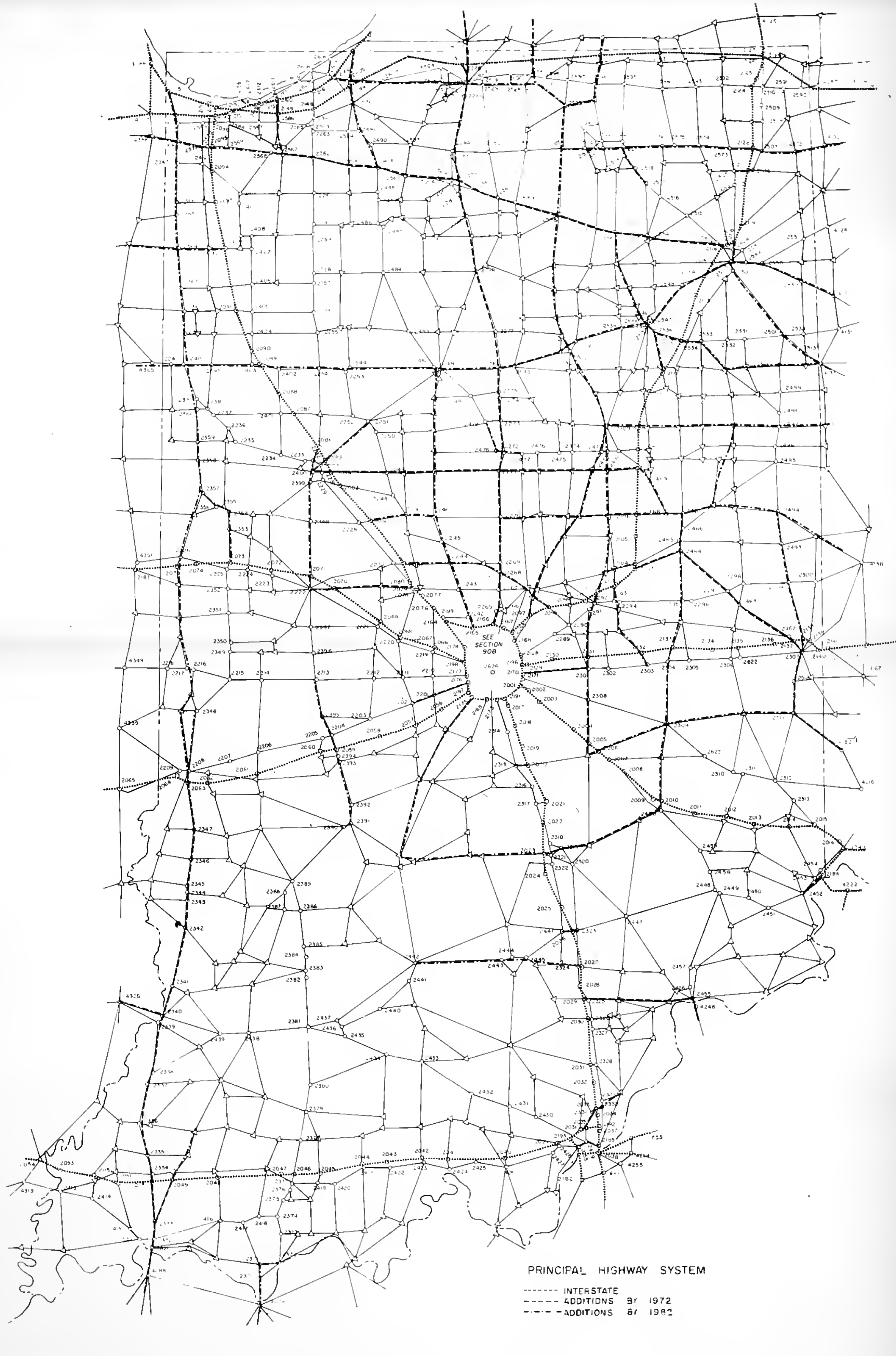

FIGURE 3. PROPOSED PRINCIPAL STATE HIGHWAY SYSTEM OF INDIANA - 1972 AND 1982 PROJECTIONS

by 1972 are those which had a link factor of 350 or more as calculated in this study. Those which had a link factor of 180 to 350 will require multilane design between 1972 and 1982.

The four subsystems of the State Highway System of Indiana as suggested by this research for 1972 are shown in Figure 4.

The Primary State Highway System includes those highways with link factors between 125 and 350. The lower value is representative of a 1962 traffic volume of about 2,600 vehicles per day so that, with a four per cent annual growth rate, the 1972 volume would be about 4,000 vehicles per day.

This projected volume of 4,000 was used because it represents the point at which high standards for two-lane rural highway design are often recommended by state highway departments. This proposed system for 1972 also includes those highways with link factors between 180 and 350 which are suggested for transfer to the Principal System between 1972 and 1982.

The Primary System was also selected to ensure the inter-connectivity of cities over 5,000 with the Principal System. Similar nearby cities in adjacent states as well as the major routes of adjacent states were also considered.

The Secondary State Highway System was selected to provide for the interconnection of all county seats and also to provide a general coverage of all areas of Indiana. A minimum link factor of 50 was used because its use appeared to provide good overall service to most areas of the State and included most highways with a 1972 volume of approximately 1,000 vehicles per day or more. Most of the small Indiana cities would be served by this system.

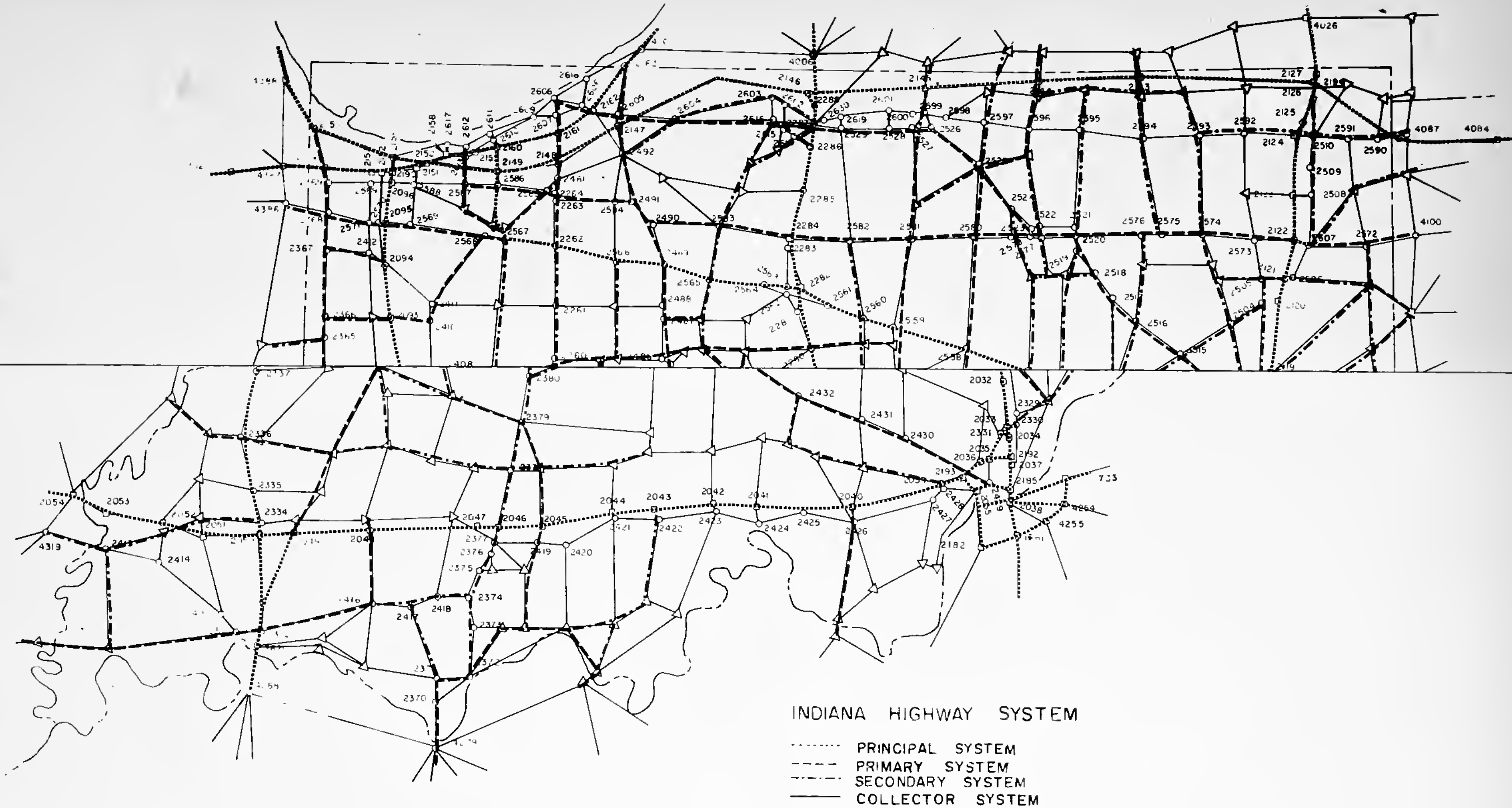

FIGURE 4. PROPOSED SUBCLASSIFICATION OF THE STATE HIGHWAY SYSTEM OF INDIANA - 1972 PROJECTIONS

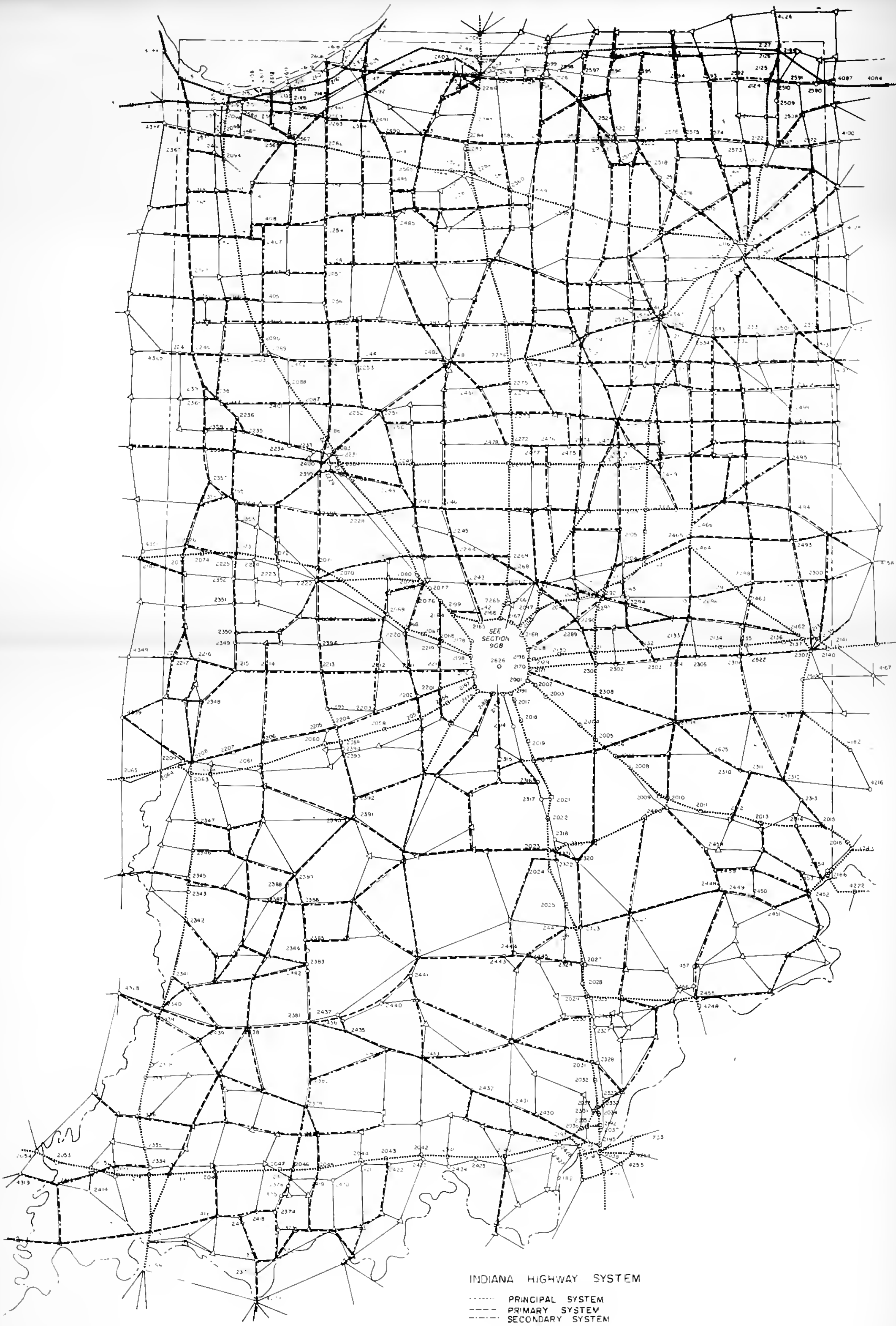

FIGURE 4. PROPOSED SUBCLASSIFICATION OF THE STATE HIGHWAY SYSTEM OF INDIANA - 1972 PROJECTIONS

With regard to the selection of each of the four subsystems, it is important to note that the factor limits of each subsystem were not strictly adhered to in all cases. Each subsystem was selected so that it was integrated with previously designated subsystems and so that there were no isolated sections unconnected to either an equal or higher system.

Thus, some flexibility in selecting the subsystems was necessary to achieve an integrated, interconnected highway system serving all areas of the State.

The remaining highways in the current state highway system, after selection of the three subsystems discussed above, include some highway sections which should be considered for deletion from the State highway system. Their low, in some cases zero, link factor indicates that the service they provide is local in character and that the counties, rather than the state, should be responsible for them. All the currently remaining state highways, however, are shown in Figure 4 as belonging in the Collector System.

Conclusion

It is suggested that the validity of the procedure described in this paper has been demonstrated. However, the need certainly exists for refinements and additonal model development. Further study of the following points is recommended:

1. Determination of the effect of distance between cities on intercity travel.

2. Evaluation of other intercity traffic desire models and a determination of practical restrictions on the use of these models.

3. The development of models to explain the amount of locally generated traffic entering urban areas and that which exists on rural highways.

4. The determination of the optimal number of State highway subsystems and the development of methods for the proper allocation of available funds to each subsystem.

5. The determination of necessary additions to the Indiana State highway subsystems to accommodate such special purposes as service to major airports, institutions, recreational areas, and other heavy traffic generators.

Serious consideration should be given to recalculating the desire factors in 1970 when new population figures and traffic volume data will be available. Nothing is more important in the field of planning than the continuing reevaluation of plans as more up-to-date information becomes available on the ever-changing conditions of a viable society.

LIST OF REFERENCES

1. Vodrazka, Walter C., Subclassification of the State Highway System of Indiana Based on Synthesis of Intercity Travel, Ph.D. Thesis, Purdue University, Lafayette, Indiana, June, 1968.

2. System Classification - Basis for Sound Highway Policy, Automotive Safety Foundation Report Number 8, Washington, D. C. 1960.

3. A Guide for Functional Highway Classification, Draft Prepared by AASHO-NACO Joint Subcommittee on Functional Highway Classification, Washington, D. C., May 1, 1964.

4. State Interest in Highways - A Report on Highway Classification, Volumes 1 and 2, for the Washington State Legislature by the Washington State Council for Highway Research, Seattle, Washington, 1952.

5. Ellis, Frederick F., A Proposed System of Highway Classification for the State of New Mexico, New Mexico State Highway Department, Santa Fe, New Mexico, 1965.

6. Highway System Classification, A Legal Analysis, Part I, Highway Research Board, Special Report 42, Washington, D. C., 1959.

7. Highway System Classification, A Legal Analysis, Part II, Highway Research Board, Special Report 85, Washington, D. C., 1965.

8. A Ten-Year National Highway Program, A Report to the President, The President's Advisory Committee on a National Highway Program, Superintendant of Documents, U. S. Government Printing Office, Washington, D. C., January, 1955.

9. Matson, T. M., Smith, W. S., and Hurd, F. W., Traffic Engineering, McGraw-Hill Book Company, Inc., 1955, p. 117.

10. Highway Capacity Manual - 1965, Highway Research Board, Special Report 87, Washington, D. C., 1965.

11. Traffic Assignment Manual, Bureau of Public Roads, U. S. Government Printing Office, Washington, D. C., 1964.